



National Institute of Standards & Technology

Certificate

Standard Reference Material[®] 4415H

Xenon-133 Radioactivity Standard

Lot Number 37

Ampoule 1

This Standard Reference Material (SRM) consists of a standardized and certified quantity of radioactive xenon-133 and non-radioactive xenon gas, unpressurized, in a stable and homogeneous mixture. It is intended primarily for the calibration of instruments that are used to measure radioactivity. A unit of SRM 4415H consists of approximately 5 mL of gas, whose composition is specified in Tables 1 and 2, contained in a flame-sealed borosilicate-glass ampoule.

The certified **xenon-133** activity value, at a **Reference Time of 1000 EST, 19 June 2014**, is:
(15.63 ± 0.34) GBq

A NIST certified value, as used within the context of this certificate, is a value for which NIST has the highest confidence in its uncertainty assessment. It is a “measurement result” [1] obtained directly or indirectly from a “primary reference measurement procedure” [2]. The certified value is traceable to the derived SI unit, becquerel (Bq).

Additional physical, chemical, and radiological properties for this SRM, as well as details on the standardization method, are given in Tables 1 and 2. Uncertainties for the certified quantities are expanded ($k = 2$). The uncertainties are calculated according to the ISO and NIST Guide [3,4]. Table 3 contains a specification of the components that comprise the uncertainty analyses.

Expiration of Certification: The certification of **SRM 4415H** is valid, within the measurement uncertainty specified, within its half-life-dependent useful lifetime, provided the SRM is handled in accordance with instructions given in this certificate (see “Instructions for Handling and Storage”). The certification is nullified if the SRM is damaged, contaminated, or otherwise modified.

Maintenance of Certification: NIST will monitor this SRM over the period of its certification. If substantive technical changes occur that affect the certification, NIST will notify the purchaser.

Radiological and Chemical Hazard: Consult the Safety Data Sheet (SDS), enclosed with the SRM shipment, for radiological and chemical hazard information.

This SRM was prepared in the Physical Measurement Laboratory, Radiation Physics Division, Radioactivity Group, M.P. Unterwiesing, Group Leader. The overall production, technical direction and physical measurement leading to certification were provided by R.K. Young and D.B. Golas, Guest Researchers from NRMAT, Incorporated.

Support aspects involved in the issuance of this SRM were coordinated through the NIST Measurement Services Division.

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Table 1. Certified Activity of SRM 4415H, Lot 37, Ampoule 1

| | |
|---|------------------------------|
| Radionuclide | Xenon-133 |
| Reference time | 1000 EST 19 June 2014 |
| Massic activity of the solution | 15.63 GBq |
| Relative expanded uncertainty ($k = 2$) | 2.2 %^(a) |

^(a)The uncertainties on certified values are expanded uncertainties, $U = ku_c$. The quantity u_c is the combined standard uncertainty calculated according to the ISO and NIST Guides [3,4]. The combined standard uncertainty is multiplied by a coverage factor of $k = 2$ and was chosen to obtain an approximate 95 % level of confidence.

Table 2. Uncertified Information of SRM 4415H, Lot 37, Ampoule 1

| | |
|---|---|
| Source description | Gas in flame-sealed borosilicate-glass ampoule |
| Ampoule specifications | Length 4.5 cm Outside diameter 1.5 cm Wall thickness $(0.12 \pm 0.02) \text{ cm}^{(a)}$ Volume 5 mL |
| Source composition | Approximately $0.04 \text{ mol}\cdot\text{L}^{-1}$ naturally-abundant non-radioactive xenon, at a pressure of $(80 \pm 16) \text{ kPa}^{(a)}$, spiked with radioactive xenon-133 |
| Photon-emitting impurities (activity ratios at reference time) | $^{131\text{m}}\text{Xe}/^{133}\text{Xe}$: $(5.2 \pm 1.6) \times 10^{-3}$ ^(a,b) $^{133\text{m}}\text{Xe}/^{133}\text{Xe}$: $(2.4 \pm 0.7) \times 10^{-3}$ |
| Half lives used | $^{131\text{m}}\text{Xe}$: $(11.962 \pm 0.020) \text{ d}^{(c)}$ ^{133}Xe : $(5.2474 \pm 0.0005) \text{ d}$ $^{133\text{m}}\text{Xe}$: $(2.198 \pm 0.013) \text{ d}$ |
| Calibration method (and instruments) | Measurements of ionization current ratios relative to radium-226 reference sources using NIST pressurized "4π"γ ionization chamber "A" calibrated using an ampoule of xenon-133 gas whose activity was determined using the NIST length-compensated internal gas proportional counters. |

^(a)The stated uncertainty is two times the standard uncertainty.

^(b)The gas was measured for photon-emitting impurities on 17 June 2014. The estimated lower limits of detection for photon-emitting impurities, expressed as photon emission rates per Bq of xenon-133, as of 19 June 2014 were:

$6 \times 10^{-4} \text{ s}^{-1}\cdot\text{Bq}^{-1}$ for energies between 40 keV and 95 keV,
 $7 \times 10^{-5} \text{ s}^{-1}\cdot\text{Bq}^{-1}$ for energies between 100 keV and 1440 keV,
 $9 \times 10^{-5} \text{ s}^{-1}\cdot\text{Bq}^{-1}$ for energies between 1450 keV and 1480 keV, and
 $5 \times 10^{-5} \text{ s}^{-1}\cdot\text{Bq}^{-1}$ for energies between 1490 keV and 2000 keV,

provided that any impurity photons are separated in energy by four keV or more from photons emitted in the decay of xenon-133.

^(c)The stated uncertainty is the standard uncertainty. See reference 5.

Table 3. Uncertainty Evaluation for the Massic Activity of SRM 4415H, Lot 37

| | Uncertainty component | Assessment Type ^(a) | Relative standard uncertainty contribution on massic activity of xenon-133 (%) |
|---|--|--------------------------------|--|
| 1 | Ionization-chamber measurement precision for this sample; standard deviation of the mean for two sets of 10 measurements | A | 0.02 |
| 2 | "4 π " γ ionization-chamber calibration factor | B | 0.31 |
| 3 | Correction for photon-emitting impurities in this sample | B | 0.03 |
| 4 | Radium-226 reference sources ratios; estimated standard deviation | A | 0.09 |
| 5 | Decay correction for radium-226 reference source to correct the calibration factor (for half-life uncertainty of 0.44 %) | B | 0.008 |
| 6 | Ionization-chamber charge collection | B | 0.05 |
| 7 | Decay correction for xenon-133 (for half-life uncertainty of 0.010 %) | B | 0.00001 |
| 8 | Detection limits for photon-emitting impurities | B | 0.06 |
| 9 | Correction for sample height positioning during measurements | B | 1 |
| Relative combined standard uncertainty | | | 1.1 |
| Relative expanded uncertainty ($k = 2$) | | | 2.2 |

^(a)Type A denotes evaluation by statistical methods; B denotes evaluation by other methods.

INSTRUCTIONS FOR HANDLING AND STORAGE

Handling: If the ampoule is transported, it should be packed, marked, labeled, and shipped in accordance with the applicable national, international, and carrier regulations. The gas in the ampoule is a dangerous good (hazardous material) because of the radioactivity. The ampoule should be opened only by persons qualified to handle radioactive material. Appropriate shielding and/or distance should be used to minimize personnel exposure. Refer to the SDS for further information.

Storage: SRM 4415H should be stored and used at a temperature between 5 °C and 65 °C. The ampoule (or any subsequent container) should always be clearly marked as containing radioactive material.

REFERENCES

- [1] JCGM 200:2012; *International Vocabulary of Metrology - Basic and General Concepts and Associated Terms (VIM)* (2008 version with Minor Corrections), 3rd edition; Joint Committee for Guides in Metrology: BIPM, Sèvres Cedex, France; p. 19 (2012); available at http://www.bipm.org/utis/common/documents/jcgm/JCGM_200_2012.pdf.
- [2] JCGM 200:2012; *International Vocabulary of Metrology - Basic and General Concepts and Associated Terms (VIM)* (2008 version with Minor Corrections), 3rd edition; Joint Committee for Guides in Metrology: BIPM, Sèvres Cedex, France; p. 18 (2012); available at http://www.bipm.org/utis/common/documents/jcgm/JCGM_200_2012.pdf.
- [3] JCGM 100:2008; *Guide to the Expression of Uncertainty in Measurement*; (ISO GUM 1995 with Minor Corrections), Joint Committee for Guides in Metrology: BIPM, Sèvres Cedex, France (2008); available at http://www.bipm.org/utis/common/documents/jcgm/JCGM_100_2008_E.pdf.
- [4] Taylor, B.N.; Kuyatt, C.E.; *Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results*; NIST Technical Note 1297, U.S. Government Printing Office: Washington, DC (1994); available at <http://physics.nist.gov/Pubs/>.
- [5] Laboratoire National Henri Becquerel; *Table of Radionuclides, Recommended Data* (^{131m}Xe updated 20 January 2014, ¹³³Xe updated 16 February 2009, and ^{133m}Xe updated 17 January 2012); available at http://www.nucleide.org/DDEP_WG/DDEPdata.htm (accessed June 2014).

Users of this SRM should ensure that the Certificate in their possession is current. This can be accomplished by contacting the SRM Program: telephone (301) 975-2200; fax (301) 948-3730; e-mail srminfo@nist.gov; or via the internet at <http://www.nist.gov/srm>.